				Olmsted	K2
(Salem Corners)					
				St. Louis	K2
(Lavell)					
				Stearns	K2
(St. Stephen)					
893-894	12.50 KHz	805.581250 MHz	775.581250 MHz	Beltrami	L1
(Washkish)					
				Crow Wing	L1
(Swanburg)					
				Goodhue	L1
(Zumbrota)					
				Grant	L1
(Herman)					
				Lake	L1
(Finland)					
				Norman	L1
(Ada)					
				Renville	L1
(Hector)					
				Washington	L1
(SA1)					
895-896	12.50 KHz	805.593750 MHz	775.593750 MHz	Itasca	L2
(Dixon Lookout)					
				Jackson	L2
(Brewster)					
				Lake	L2
(Silver Cliff)					
				Le Sueur	L2
(Kilkenny)					
				Morrison	L2
(Lincoln)					
				Pennington	L2
(Thief River Falls)					
				Sherburne	L2
(Zimmerman)					
				St. Louis	L2
(Meadowlands & ElephantLk)					
				Winona	L2
(Aren Dahl)					
				Yellow Medicine	L2
(Oshkosh)					
901-904	25.00 KHz	805.637500 MHz	775.637500 MHz	Blue Earth Koochiching Lac qui Parle Mower Murray Red Lake Stearns Wadena Washington	
905-908	25.00 KHz	805.662500 MHz	775.662500 MHz	Crow Wing Hennepin Traverse Wabasha	

909-912	25.00 KHz	805.687500 MHz	775.687500 MHz	Benton	
				Clay	
				Douglas	
				Hubbard	
				Jackson	
				Pennington	
				Renville	
				Rice	
				St. Louis	
913-916	25.00 KHz	805.712500 MHz	775.712500 MHz	Faribault	
				Fillmore	
				Lyon	
				Wright	
917-920	25.00 KHz	805.737500 MHz	775.737500 MHz	Beltrami	
				Cook	
				Cottonwood	
				Dodge	
				Kandiyohi	
				Otter Tail	
				Pine	
				Ramsey	
925-926	12.50 KHz	805.781250 MHz	775.781250 MHz	Aitkin	J1
(Sandy Lake)					
				Clearwater	J1
(Bagley)					
				Douglas	J1
(Hoffman)					
				Goodhue	J1
(Cannon Falls)					
				Houston	J1
(Spring Grove)					
				Jackson	J1
(Lakefield)					
				Kanabec	J1
(Mora)					
				Kittson	J1
(Lake Bronson)					
				Koochiching	J1
(Mizpah)					
				Renville	J1
(Sacred Heart)					
				St. Louis	J1
(Virginia/Midway)					
927-928	12.50 KHz	805.793750 MHz	775.793750 MHz	Anoka	J2
(SN2)					
				Chisago	J2
(SN2)					
				Cottonwood	J2
(Walnut Grove)					
				Lake	J2
(Beaver Crossing)					
				Lake of the Woods	J2
(Muligan Lake)					
				Morrison	J2
(Freedhem)					

				Olmsted	J2
(Cummingsville)					
				Wilkin	J2
(Everdell)					
929-930	12.50 KHz	805.806250 MHz	775.806250 MHz	Aitkin	K1
(Arthyde)					
				Cook	K1
(Tofte)					
				Itasca	K1
(Itasca County - Tower)					
				Polk	K1
(Trail)					
				Renville	K1
(Morton)					
				Swift	K1
(Appleton)					
				Wabasha	K1
(Bear Valley)					
				Wadena	K1
(Sebeka)					
				Waseca	K1
(New Richland)					
931-932	12.50 KHz	805.818750 MHz	775.818750 MHz	Becker	K2
(Flat Lake Lookout)					
				Beltrami	K2
(Hines)					
				Cottonwood	K2
(Windom)					
				Lake	K2
(Lake One)					
				Le Sueur	K2
(LeSueur)					
				Marshall	K2
(Old Mill St Pk)					
				Olmsted	K2
(Salem Corners)					
				St. Louis	K2
(Lavell)					
				Stearns	K2
(St. Stephen)					
933-934	12.50 KHz	805.831250 MHz	775.831250 MHz	Beltrami	L1
(Washkish)					
				Crow Wing	L1
(Swanburg)					
				Goodhue	L1
(Zumbrota)					
				Grant	L1
(Herman)					
				Lake	L1
(Finland)					
				Norman	L1
(Ada)					
				Renville	L1
(Hector)					

				Washington	L1
(SA1)					
935-936	12.50 KHz	805.843750 MHz	775.843750 MHz	Itasca	L2
(Dixon Lookout)					
				Jackson	L2
(Brewster)					
				Lake	L2
(Silver Cliff)					
				Le Sueur	L2
(Kilkenny)					
				Morrison	L2
(Lincoln)					
				Pennington	L2
(Thief River Falls)					
				Sherburne	L2
(Zimmerman)					
				St. Louis	L2
(Meadowlands & ElephantLk)					
				Winona	L2
(Aren Dahl)					
				Yellow Medicine	L2
(Oshkosh)					
941-944	25.00 KHz	805.887500 MHz	775.887500 MHz	Becker	
				Blue Earth	
				Itasca	
				Lake of the Woods	
				Murray	
				Red Lake	
				Stearns	
				Washington	
945-948	25.00 KHz	805.912500 MHz	775.912500 MHz	Crow Wing	
				Grant	
				Hennepin	
				Lake	
				Marshall	
				Olmsted	
				Yellow Medicine	

Attachment 9

Grouping and Allotment Plan For 700 MHz Statewide Channels 12/23/04

Groups	700 MHz Statewide Channels	
A_1*	25-26	645-646
	65-66	685-686
A_2	27-28	647-648
	67-68	687-688
B_1	29-30	649-650
	69-70	689-690
B_2	31-32	651-652
	71-72	691-692
C_1	33-34	653-654
	73-74	693-694
C_2*	35-36	655-656
	75-76	695-696

* Adjacent to Interop and Reserve Channels

Groups	700 MHz Statewide Channels	
D_1*	185-186	805-806
	225-226	845-846
D_2	187-188	807-808
	227-228	847-848
E_1	189-190	809-810
	229-230	849-850
E_2	191-192	811-812
	231-232	851-852
F_1	193-194	813-814
	233-234	853-854
F_2*	195-196	815-816
	235-236	855-856

* Adjacent to Interop and Reserve Channels

Groups	700 MHz Statewide Channels	
G_1*	105-106	725-726
	145-146	765-766
G_2	107-108	727-728
	147-148	767-768
H_1	109-110	729-730
	149-150	769-770
H_2	111-112	731-732
	151-152	771-772
I_1	113-114	733-734
	153-154	773-774
I_2*	115-116	735-736
	155-156	775-776

* Adjacent to Interop and Reserve Channels

Groups	700 MHz Statewide Channels	
J_1*	265-266	885-886
	305-306	925-926
J_2	267-268	887-888
	307-308	927-928
K_1	269-270	889-890
	309-310	929-930
K_2	271-272	891-892
	311-312	931-932
L_1	273-274	893-894
	313-314	933-934
L_2*	275-276	895-896
	315-316	935-936

* Adjacent to Interop and Reserve Channels

Attachment 10

Attachment 10

A PLAN FOR ADDING A HIGH-SPEED MOBILE DATA COMMUNICATIONS LAYER TO THE REGION-WIDE PUBLIC SAFETY RADIO COMMUNICATIONS SYSTEM-PHASE ONE

INTRODUCTION

A regional 800 MHz, digital modulation, trunked voice radio system has been implemented for use by government entities in the Minneapolis-St. Paul metropolitan region. This system is designed to bring improved interoperability, less channel congestion, spectral efficiency and lower cost for two-way voice radio communications through the sharing of expensive infrastructure to the users of the system.

There is widespread interest among government entities in the Minneapolis-St. Paul metropolitan region in exploring the potential for a mobile data communications network addition to the voice network if a shared data network can also provide significant benefits to users.

Any new mobile data communications network implemented must have much higher data throughput, and much higher data transfer rates, than existing systems to meet needs. The Federal Communications Commission (FCC) has made 48, wideband, data communications only radio channels available in the 700 MHz band of the radio frequency spectrum. Each of those channels can be used for much higher data transfer rates than is possible today. In addition, the FCC will permit aggregating two or three of those wideband channels together as a single very wideband channel, which will make even much higher rates of data transfer available. Use of these wideband radio channels will require the design and construction of a data communications radio network layer addition to the voice radio network, although the data communications network can utilize significant parts of the voice network.

At present, during 2003, there are several commercial high data rate mobile data communications networks being implemented in the region. These networks can provide high data transfer rates, and the capacity to transfer large files. One or several of these commercial networks may be used for some, or possibly all, of the mobile data communications needs of government entities in the region. These networks can be used through payment of ongoing usage fees without a capital investment in network infrastructure.

Each data communications network may require use of a different mobile data modem and radio. Mobile data computers, and software for use in those mobile

computers, and the software used in the host systems is likely to be decided independently of the data communications network used.

It is technically feasible to use more than one of the government and commercial data communications networks to best meet the needs of any particular entity. It is probable that no one combination of networks will be best for every user.

As with the design basis for the regional voice radio system, it is probable that there will be improved spectral efficiency, lower cost, higher reliability, higher data rates, improved interoperability and more functionality such as regional roaming if a region wide design for use of the 48, wideband, data only radio channels is implemented rather than implementation of many uncoordinated local systems results. The wideband radio channels are available for use and there are several large government data radio communications users in the region that must implement new mobile data communications systems by the middle or end of 2004. The intent of this document is to recommend the direction to follow for an optimum coordinated use of the 48, wideband, data only radio channels in the Minneapolis-St. Paul region. Other commercial data communications networks available for use are mentioned only where they may have decision impacts on the design of a government 700 MHz regional data communications layer with the existing regional 800 MHz voice network.

1. DATA COMMUNICATIONS NEEDS

1.1 Needs Considerations

Consideration of any changes to existing mobile data communications systems must include an evaluation of existing and emerging needs. Are the existing systems capable of meeting the needs, including emerging needs for data communications? If not, which, if any, possible alternative data communications systems may be able to satisfy those needs?

Issues to be considered in the development of a preliminary design for a government data communications network are those involving wide area, mobile, wireless data communications. Wide area may be thought of as an entire city or an entire county or part of the geographic area of a state. Wireless data communications in smaller areas such as a single building or a campus of associated buildings should be designed using different technical approaches than the technical approach that would be appropriate for a wide area system. The term "mobile" as used in this document, refers to equipment mounted in vehicles as well as to hand held data communications devices.

1.2 Factors that Impact the Ability to Meet Data Communications Needs

Unlike wireline data communications, wireless data communications capabilities are essentially shaped by the capacity for transmission of data. No matter what form of wireless data communications system is employed, there is a finite limit on the amount of data that can be transmitted. For any given data transmission

medium, the amount of information that can be transmitted is impacted by a number of factors that are discussed in this subsection of this document.

The needs that can be met are impacted by the functions that are to be supported by the data communications network. For example, more of the transmission medium capacity will be utilized if digital dispatching functions are supported in addition to database access than if only database access functions are supported.

The ability of the transmission medium to support data communications is also impacted by what use is being made of the data communications system within specific functional areas. For example, in regard to database access, approximately 60% of all database inquiries for law enforcement entities, other than state police or state patrol entities, are motor vehicle registration checks. Will the inquiry result only in a return of basic information on the motor vehicle registration, or will the system automatically also perform a driver license record check on the registered owner of a vehicle as well as checks of local records systems and NCIC on the person listed as the registered owner. Those additional automatic inquiries can be an extremely valuable use of the database access function, however, those additional inquiries utilize more of the finite amount of transmission medium capacity.

The way in which the data communications system is utilized in supporting specific functions also impacts the information that can be transmitted. For example, when a database inquiry is entered, how is the record returned over the wireless transmission medium? A motor vehicle registration record may be several pages in length, however, a law enforcement officer on patrol or traffic duty may only be interested in a small amount of specific information from that record. The specific information the officer may wish to have includes the make, model, year, body style, color and VIN of a vehicle with a specific plate number. The officer may also wish to know the name and date of birth of the registered owner of the vehicle. Far more returns can be provided to far more inquiries with the same data transmission medium capacity if only the information that the officer normally wants is stripped out of the total motor vehicle registration record, reformatted, and transmitted to the officer.

Another factor that impacts the amount of information that can be sent over a transmission medium is the data throughput that can be transmitted within a specific amount of radio frequency spectrum. The throughput is related to the data rate per hertz of spectrum that can be transmitted as well as the usable data of the total amount of data being transmitted. Not all of the data that is transmitted is usable data as some of the transmitted data must be used as header overhead and error correction as well as signalling. Small amounts of header overhead, error correction and signalling result in more data throughput for a given data rate per hertz of spectrum used.

The area to be covered from a single site and the terrain surrounding that site has an impact on the throughput capability of a data transmission medium. That is because larger geographic areas and unfavorable terrain result in lower field strength of the wireless signal arriving at a receiver. Lower signal levels result in more multi-path fading periods. Any multi-path fading period cuts out part of the data that was transmitted so that the data must be retransmitted. The more retransmissions there are, the less usable data that can be received over a given transmission medium.

1.3 Typical Current Uses for Mobile Data Communications

Most mobile data communications systems in the United States and Canada are used by law enforcement agencies. There are a number of fire service entities that also use mobile data communications and a few emergency medical service agencies also use mobile data communications. The information on current uses for mobile data communications that are discussed in this subsection of this report are mainly related to law enforcement uses as this is the major use at this time; however, some fire service and EMS needs are also described.

All, or nearly all, law enforcement mobile data communication systems have access to databases, particularly state databases for motor vehicle registrations and driver licenses. Up until about ten years ago, about 80% of all mobile data communications systems were limited to those database access uses.

In addition to database access, about four out of five current mobile data communications systems also handle basic computer aided dispatch system related functions. Those basic computer aided dispatch functions include digital dispatch of event messages, automatic status updating without dispatcher involvement, log-on/log-off, transmission of freeform administrative messages, and emergency signalling.

About two out of five of the mobile data communications systems currently in use include advanced computer aided dispatch functions. Advanced computer aided dispatch functions include an easy way for a person in a vehicle to create a self-initiated event, creation and storage and transmission of E-mail messages, retrieval of active event summaries, retrieval of active unit summaries, and access and manipulation of local databases especially those related to the master name index and vehicle files.

Most existing mobile data communications systems operating at 19.2 to 43 kBPS have the transmission capacity required to support all of these functions including the advanced computer aided dispatch support functions. There are some systems, however, that do not have the transmission capacity to support all of the functions described above, especially at least some of those mentioned as advanced CAD function support. In particular, at-will retrieval of active event summaries and active unit summaries functions are not possible due to the transmission capacity limitations in some systems.

1.4 Currently Unmet Needs

There are a number of needs that have been identified but that are not often included in mobile data communications systems. These needs have significant interest on the part of users of mobile data communications, but they cannot be met generally due to the transmission capacity limitations.

The most frequently mentioned need that is generally unmet, especially in larger mobile data communications systems, is the preparation and transmission of reports. Over the past ten years, most law enforcement entities have asked for the ability to produce reports and to transmit them by wireless means. Somewhere around 40% of the events in which a law enforcement officer responds to a location require the preparation of one or more reports regarding the event. At present, it is frequent that the law enforcement officer waits until the end of the shift and then prepares all of the reports for the events requiring reports that the officer handled during the past shift. Often the officer prepares part of the report by filling in blanks and then dictates text information.

It is not uncommon to find that it may take days, or even weeks, before the report is transcribed. After transcription, the report must be reviewed before it is put into a records system. At the time of review, specific information that is required may be found to be missing and the reviewer has to track down the officer to try to get that information to add to the report before it is filed in the records system. This is a very inefficient way of handling of information, it often leads to important information being left out of the report, and the information does not become available in the records systems until long after the event occurred. The value of information in a records system tends to diminish rapidly, in days, after an event occurs. If the information from an event report isn't even entered into a records system for several weeks, the value of that information is much less than if it were made available immediately after the event is closed.

A modern records management system fully integrated with a mobile data communications system can make it possible for an officer in a vehicle to call up a report form and command that a computer aided dispatch system populate as many fields in the report form as possible. The officer then may change information in specific fields and add information in other fields and type a few lines of remarks for most reports as most reports do not require an extensive amount of remarks type documentation. If a reviewer is available to review those reports, when they are transmitted immediately by wireless means, any information that needs to be added or changed can be obtained while the officer is still on duty during the same shift as the event occurred. If the report is acceptable, it can be entered in the records system where it is available to all persons authorized to have access to records files. This is the basis for the very large and widespread interest in being able to transmit law enforcement reports by wireless means to the records handling process. The reason that this

demand is not satisfied is related to the limitations on data throughput in most mobile data communications systems operated by larger entities.

There are many unmet needs for the fire service including the following:

- Access to preplans including sketches of building floor plans and drawings showing important building features such as the locations of standpipes and fire department emergency panels.
- Access to hazard information by wireless communications by firefighters who are en route to a fire scene.
- Access to premise information, especially to names and telephone numbers of building owners and managers.
- Access to inspection reports.
- Access to information in regard to water main sizes.
- Access to maps showing hydrant locations in the vicinity of a fire scene.

Preplans, premise information, the sizes of water mains and hydrant locations can help firefighter personnel save time as they arrive at the scene of a involved structure fire. Time is of the essence in suppression activities related to a structure fire. In controlled fires in residential structures, it has been determined that if water can be applied within four minutes after a flame breaks out, much of the structure can be saved. If a flame has been in progress for more than four minutes, the structure will often be a total loss even though water and effective suppression techniques are applied. Many fire departments have strategically located a large number of fire stations housing first line fire apparatus and crews available to leave in a short time after an alarm is received. The number of fire stations and fire apparatus is not related to the total amount needed to fight fires at any given time, but is related to the average response time to any point in the geography covered by a fire department. The rule is, the more fire stations there are in a geographic area, the shorter the distance from any fire station to a structure fire and therefore the shorter is the response time. It is very expensive for the public to maintain a large number of fire stations and fire apparatus and personnel to respond, however, that is a cost that the public is generally willing to bear in order to try to reduce the loss of property and of lives in fire events. The information that can be made available to firefighters can help reduce the time before water is applied and therefore is a relatively inexpensive means for further reducing the time required between the initial alarm and the application of water and effective fire suppression techniques.

Access to hazard information, inspection reports, and preplans can be extremely important to increasing the safety of firefighters involved in fire suppression activities in a working structure fire. It is important to know, for example, that 10,000 gallons of benzene is stored in a building that has a common wall with a building that is on fire.

It is for these reasons that the fire service, in general, is trying every means possible to provide this kind of information to firefighter personnel who are en route to a working structure fire event. At present, most fire agencies provide much of this information stored on laptop computers in fire apparatus. Unfortunately, it is virtually impossible to keep the files stored on laptop computers in fire apparatus up-to-date. Recent hazard reports, or inspection reports, or changes in preplans due to remodeling work or other reasons simply cannot be continuously updated in laptop computers scattered over a large number of pieces of fire apparatus. That is why most fire agency command personnel are extremely interested in the ability to provide that information by wireless means to personnel in responding fire apparatus from a central computer system that can be updated immediately as new information becomes available.

Emergency Medical Service (EMS) entities also have unmet wireless data communications needs including:

- Access to the same hazard information that firefighters need.
- The ability to prepare and transmit patient medical information records.
- The ability to prepare and transmit reports related to business activities of an emergency medical entity.

EMS personnel need the same kinds of information as firefighters to become more effective and so that EMS personnel may operate more safely in the field. It is also proven to be helpful if basic patient medical information can be prepared and transmitted in digital form while a patient is being transported to an emergency room facility.

EMS ambulance apparatus is quite often moving to different quarters to fill in for an ambulance that is on an emergency or other run or to get back to quarters from a run to a medical facility. For that reason, managers of EMS agencies have identified a significant need for transmission of Automatic Vehicle Location (AVL) data from EMS vehicles to dispatch locations. The AVL information can be used to alert the closest ambulance to respond even when many ambulances are en route rather than in station.

The EMS personnel may spend only a short time in a fixed physical location that may or may not be equipped with data communications equipment that would allow the transmission of reports related to business activities. It is for that reason that EMS agency management personnel are extremely interested in the ability to transmit business activity data by wireless means.

1.5 Emerging Needs

In addition to needs that are currently being met and needs that generally are currently unmet, there are additional emerging needs for wireless mobile data

communications. Many of these emerging needs require the transmission of very large amounts of data and will have a profound effect on the data transmission capacity requirements for wireless data communications by government and government related entities.

Examples of emerging law enforcement needs include the following:

- Transmission of high-resolution, full color pictures. Many local records management systems are adding full color pictures to person records. Law enforcement personnel are interested in receiving high-resolution, full color pictures that are part of a driver's driver license record. NCIC 2000 information states that high-resolution, full color pictures are also soon to be available and will need to be transmitted by wireless data communications means. The pictures typically will require approximately 72 KB of data, even when compressed.
- There is rapidly increasing interest in the transmission of fingerprint information from the field to automatic fingerprint identification systems to aid in identifying persons. As with the transmission of full color pictures, as much as 72 KB of data must be transmitted in order to send several fingerprints by wireless means, even with compression.
- Access to an effective crime analysis set of functions that is part of modern law enforcement records management systems.

The cost to maintain a law enforcement officer in the field is very high. Law enforcement officers are relatively well paid and have very high retirement and other benefit related costs; higher retirement costs than other government employees because law enforcement personnel are able to retire at a younger age after fewer years of service. In addition, there are high ongoing training costs, high vehicle costs and high costs for uniforms and equipment related to the work of law enforcement officers. All of those related functional issues add substantial cost to maintaining a law enforcement officer in the field. Most law enforcement entities have determined that it costs in excess of $100,000 a year to keep each law enforcement officer active in the field.

With ever tightening government budgets, it is becoming increasingly difficult to add more law enforcement personnel at the same time that law enforcement activity levels continue to increase faster than increases in population. It is clear to many elected officials and city managers/county administrators that some means to increase the effectiveness and efficiency of law enforcement officers must be found. Many law enforcement officers are frustrated in their inability to determine the true identity of people with whom they come in contact.

It is for that reason that there is a great interest in the ability to instantaneously pick up prints of a thumb and index finger that can be transmitted by wireless means to an automatic fingerprint identification system that can do a search of its database in a very short period of time. As time goes on, more and more

fingerprint information can be added to the central automatic fingerprint identification system databases. In that way, a positive identification of a person that an officer comes in contact with in the field can be obtained. If there is a record for that person, a copy of that record, including a high-resolution color picture of the person, can also be transmitted back to the officer by wireless means for further positive identification. By this means, the effectiveness and efficiency of law enforcement officers can be increased by a substantial amount.

If the officer is also able to have access to a modern crime analysis system into which an officer in the field can enter some characteristics related a situation the officer encounters, the automatic crime analysis system can feed the officer back possible matches for other similar events that have occurred in the past. This is an extremely powerful tool to assist officers in narrowing down possibilities related to a situation with which the officer is involved.

It is clear that the ability to electronically transmit fingerprints in real-time to an automatic fingerprint identification system and to provide in return a possible record with a picture combined with access to a sophisticated crime analysis system can result in a major increase in the effectiveness and efficiency of law enforcement officers in the field. There is a very strong interest in being able to deploy the picking up of fingerprints, transmission of pictures and providing access to a sophisticated crime analysis system all supported by wireless data communications at the earliest possible time by a majority of law enforcement entities in the United States and Canada.

Agencies, other than law enforcement entities, also have emerging wireless data communications needs. An example is Metro Transit that has an emerging need to transmit location information for a large fleet of revenue buses. The location information can then be compared to the scheduled location so that an exception message can be made available to supervisors who can then take action to keep the transit system functioning as close to scheduled performance as possible. Even without polling, there will be a need for transmission of large amounts of data because of the large number of revenue buses involved.

1.6 CriMNet

Concurrent with the development of this high-speed data communications plan, there is parallel implementation of an Integrated Justice System in Minnesota called CriMNet. CriMNet is to integrate the flow of information through all elements of criminal justice functions in a coordinated manner. CriMNet will involve the collection of event related data from dispatching operations and from follow-up investigative activities, and the manipulation and storage of that data in user-friendly formats.

The following are among the objectives for CriMNet:

- Utilize technologies to make the system as effective as possible.

- Eliminate or reduce redundant data entry.
- Make sure that the right people have access to the right information, at the right time, in the right place.

The high-speed data communications system described in this document can be the essential tool that can make those objectives for CriMNet achievable in the following ways:

- High-capacity, high-speed wireless data communications is the technology needed to allow law enforcement personnel to have access to the data stored accessible through CriMNet.
- With proper integrated system design, a high-capacity, high-speed data communications system can eliminate the redundant entry of data in reports prepared by law enforcement personnel.
- Any law enforcement officer in a vehicle can have access to all non-restricted criminal justice data accessible through CriMNet at any time using the high-speed data communications system.

1.7 Video Transmission

There are many potential uses for radio transmission of video information including:

- Transmission of full motion video from a single law enforcement officer to a dispatch center and/or command post during short-term periods associated with high-risk activities.
- Transmission of fixed frame video information for surveillance and monitoring of low risk persons and buildings.
- Surveillance of traffic flow.
- Major extraordinary events often require coordinated response by multiple agencies from multiple jurisdictions. Video signals may be available from multiple sources including commercial broadcasters. These various video signals can be valuable in coordinating activities of multiple agencies and as part of information sharing among assisting agencies working together in a command post. Maximum effectiveness in coordinating response may benefit from transmission of full motion video information to more than one location.
- Major extraordinary events such as large area forest/brush fires can be addressed more effectively with airborne generated video information transmitted to command post personnel.
- Short-range point-to-point video can be valuable in situations such as a building collapse where robotic devices are used to explore.

2. TRANSMISSION ALTERNATIVES

As mentioned in Section 1, the data transmission link is the key element that must be considered in the planning and design of a wireless mobile data communications system. That is because any wireless communications system has a finite limit as to the amount of data that can be transmitted on any given channel and a finite limit as to how much bandwidth per channel can be dedicated out of the radio frequency spectrum for mobile data uses. Since there is a upward finite limit as to how much data can be transmitted, it is essential that planning and design of any new mobile data communications system consider the transmission data rate and the effective amount of data that can be transmitted as part of the design considerations. This section of this report discusses four transmission alternatives.

2.1 Currently Used Wireless Data Communications Systems

Many of the currently used wireless data communications systems in the Minneapolis-St. Paul metropolitan area use a raw data transmission rate of 4.8 kBPS. The effective amount of data that can be transmitted on that kind of link is in the range of 2.2 to 2.4 kBPS after packet overhead, signalling, error correction and repeat transmissions are taken into account.

Current technology will permit the existing systems to be upgraded to 9.6 KBPS for NPSPAC radio channels or 19.2 to 43 kBPS for a standard 25 kHz, 5 kHz deviation radio channels. Again, those data rates are the raw data rates and the effective data rate would generally be somewhere around half those rates. With a 9.6 kBPS data communications channel, a 2-inch by 3 inch, high-resolution, full color picture can be transmitted in approximately 12 seconds if the data is compressed. With a 19.2 KBPS raw data rate channel, a 2-inch by 3 inch, high-resolution, full color picture can be transmitted in approximately 7 seconds if the data is compressed.

2.2 Commercially Available Data Transmission Services

CDPD has been an offering of the cellular telephone companies. This wireless data communication link operates at 19.2 kBPS and has an effective data rate in the area of 14 kBPS after consideration of packet overhead, signalling and other factors. CDPD is currently used by several law enforcement entities in the Minneapolis-St. Paul region including the University of Minnesota, the city of Minneapolis and Anoka County. CDPD works well and has a significant amount of capacity because channels are reused at short distances in the cellular telephone cell geographic areas. CDPD does have significant recurring costs for large, high volume entities, however, it is a very cost effective solution for small agencies like the University of Minnesota that have low volume and find it difficult to justify paying the cost of a wireless data communications infrastructure.

The approximate 14 kBPS effective data rate with CDPD is not adequate to meet current and emerging demands for mobile data communications. In addition, CDPD service is being discontinued in mid 2004; however, there are equivalent

commercial services including GPRS and new services from Nextel and others that can be used to replace CDPD.

2.3 New Wide Bandwidth Channels

In September, 1998, the FCC in Report and Order 98-101 made 48 50 kHz bandwidth radio channels available exclusively for wireless data communications by government entities. It is required that the minimum data rate on these channels be 128 kBPS. At this time (fall 2003), there are no radios or radio data modems available to operate in these wide bandwidth channels at those data rates; however, technology appears to be available from at least two manufacturers to meet the FCC requirements. One manufacturer indicates that production models of radio and modem equipment able to operate at a data rate of 128 kBPS in 50 kHz of channel bandwidth can be shipped in August of 2004. The other manufacturer proposes a step by step roll out of equipment models at ever increasing data rates until production equipment able to operate at a raw data rate of 192 kBPS in 50 kHz of channel bandwidth is available in late 2005. The discussions of the technology that might be employed indicate that an effective usable data rate of about 70 kBPS would be available on channels at a raw transmission data rate of 128 kBPS. At 70 kBPS, a 2 inch by 3 inch high-resolution, full color picture can be transmitted in one to two seconds of time with compression.

There are also 18 more 50 kHz data only 700 MHz channels for interoperability, and there is a reserve of spectrum of 54 more 50 kHz channels that may be released in the future by the FCC for data communications needs.

The FCC Report and Order that made these wideband channels available also states that a national set of rules for utilization of the channels must be developed and plans for allocation of these channels must also be developed in each of the FCC planning regions which for the Minneapolis-St. Paul region is the entire State of Minnesota. The Report and Order also required that the issue of interoperability between different systems utilizing these radio channels will need to be addressed in the future. The 700 MHz band cannot be used in areas of the United States where UHF TV stations are operating on any of Channels 60 to 69; however, there are none in the Minneapolis-St. Paul region. If a concerted effort is begun soon, eligible government entities in this region can likely receive licenses to use the 50 kHz bandwidth channels by August 2004.

It is possible to develop a regional design for a high data rate mobile data communications system in this region, and to implement the design in stages. For example, there can be a regional design and channel use plan, but only those channels needed in one or two or three counties may be implemented in the first stage. The design may show a long term need for two or three or more channels at one or more base radio sites; however, only one channel need be implemented at any site in the first stage. Vendors should be given the flexibility

to propose the most effective means for a step-by-step build out related to the technology available.

2.4 Spread Spectrum

There is spectrum available and radio equipment available that will operate in a mode referred to as spread spectrum. Spread spectrum wireless data radio equipment is capable of transmitting at data rates as high as 10 MBPS. Unfortunately, the portion of the spectrum that is available for this equipment and the wireless equipment itself result in a very limited range for spread spectrum wireless data communications fixed location radios. The range may be as little as one-quarter square mile (a circle with one-quarter mile radius) surrounding each radio site. That would mean that a very large number, perhaps 1,000 or more, of fixed location radio sites would be required to implement a government developed and owned spread spectrum wireless data communications network throughout the Minneapolis-St. Paul metropolitan region. Spread spectrum radio equipment is relatively low in cost, however, implementing a system with 1,000 radio sites and 1,000 communications link paths will be a formidable, and probably expensive, problem.

It is more likely that government owned spread spectrum technology will have application in limited areas such as an area around a location where law enforcement officers meet before leaving on patrol. The spread spectrum site would be used to automatically download large file updates such as detailed updated maps and building plans to the mobile computers.

There are commercially developed spread spectrum systems that cover substantial portions of the geographic area of the metropolitan region that may be considered by individual governments as a data communications medium. Existing spread spectrum radio systems use unlicensed portions of the spectrum and there is therefore the potential for interference with minimal or no relief available for overcoming the interference from the FCC. It is possible that the FCC may provide some additional spectrum that may be used for spread spectrum systems that will have protections from interference.

2.5 Range of Government Owned Data Communications Systems Options

Data communications issues addressed in this document are intended to suggest steps to be followed to establish the best use of 48, 50 kHz bandwidth, data communications only, 700 MHz radio channels, if government entities desire to use them in a government owned and operated system. Some, or all, government entities may decide to migrate to use of commercial services that provide data communications mediums for all of their wireless data communications needs and none of the 50 kHz bandwidth, 700 MHz channels will be needed. In addition, it is also possible that at least some governmqent entities may decide that a government owned and operated data communications system using 25 kHz bandwidth channels, or an alternative

system using the 50 kHz bandwidth channels, is the best choice for meeting needs. As guidance, it is suggested that planners considering the range of options available base analysis on ranges of raw data rates available with various technologies available, or likely to be available within a few years of the time that this document was prepared (fall 2003). Currently available raw data rates are:

- Well proven system design from one vendor – 19.2 kBPS in 25 kHz of bandwidth.
- New system design based on well proven technology from another vendor – 43 kBPS in 25 kHz of bandwidth.
- New system design – 96 kBPS in 25 kHz of bandwidth.
- New system design based on proven technology – 128 kBPS in 50 kHz of bandwidth.
- New system design – 192 kBPS in 50 kHz of bandwidth to 460 kBPS in 150 kHz of bandwidth (aggregating three adjacent 50 kHz channels into one 150 kHz channel).

3. TECHNICAL ISSUES

3.1 TCP/IP

The Internet protocol and transmission protocol have been developed and make intersystem data communications much simpler today than they were more than 10 to 15 years ago. Certainly, any design of any future wireless mobile data communications system should require that all connected systems function utilizing the TCP/IP protocol in all software and message routing.

In addition, all connected systems should be able to intercommunicate using compatible application software for word processing, spreadsheets, databases, and pictures and other graphic information. Where possible and appropriate, CriMNet standards for access to data and for intercommunication should be followed.

3.2 Transmission of Text Versus Windows

Most computers today use the Windows operating system and a word-processing software that operates under Windows. That word-processing software creates a page of text as a graphic and stores and transmits that information as a graphic. Even though there have been some attempts made to compress some of the data when it is transmitted, information transmitted in a text stream, such as a ASCII stream, results in only approximately 40% as many bits as the same amount of information as a Windows graphic. In addition, if a text stream is transmitted, it is possible to transmit only the information that appears in fields; the field headers need not be transmitted as they can be stored in the receiving computer equipment. That can mean that transmitting information as a text stream will only require about 25% as much data be

transmitted as the same information being transmitted as a Windows word-processing graphic.

Because the wireless transmission medium has a finite capacity, it is important that any future wireless data communications system be designed with strong evaluation of transmitting text information rather than Windows word-processing graphics. A smaller percentage of currently used systems do transmit information as text while a majority transmit information in the form of a Windows word graphic. This has been done in the currently used systems as it is easier for the software development people to deal with transmitting Windows word documents rather than converting the information from Windows word to a text stream.

3.3 Frequency Usage for a Government Network Using 50 kHz Bandwidth 700 MHz Channels

Currently used mobile data systems use one of two ways to utilize a group of radio frequencies. In one case, multiple sites that are required in order to cover a specific geographic area and terrain all use the same radio frequency. Other systems utilize a different radio frequency at each of the radio sites that are required to cover the area. Both systems would require the same number of radio sites to cover the same area with the same coverage performance.

In a system that uses only one frequency, the receivers at each of the radio sites are arranged in a voting configuration so that they present the best received signal through the message switch to a remote computer system. When the remote system directs a message back through the message switch to a mobile data radio, that data is steered back to the transmitter at the site where the receiver was voted. The transmitter is then keyed and when it gets up to an acceptable power level, the data that is delayed while waiting for the transmitter to come up is then transmitted. An additional amount of time is required to transmit each message as the data must be delayed while the transmitter is coming up to power. In many systems, the amount of time for the transmitter to come up may equal the message length, which effectively reduces the data rate to one-half of its actual transmission rate. This transmitter up time will be an even more significant issue as data transmission rates increase. There is some radio equipment on the market that is designed to bring the transmitter power up very quickly, however, that radio equipment costs about five times more than standard radio base station equipment. In addition, the fixed location infrastructure will try to send a message using the radio site that was last voted when the mobile transmitted in if the mobile does not initiate the transmission. The mobile unit may, however, have moved a considerable distance and may no longer be capable to receiving a message from the site that is selected by the infrastructure. In that event, the infrastructure must try retransmitting the message on other sites until it receives an acknowledgement from the mobile. This can further reduce the effective transmission throughput of the mobile data communications system. These systems are in common use, however, because

of the lack of available radio frequencies in most major metropolitan areas in the United States and Canada. Therefore, when only one frequency may be available, this is the only method that can be used even though it is quite inefficient in terms of transmission of data.

In the multiple frequency type systems that are in current use, the fixed location transmitters tend to be transmitting at all times. Those fixed location transmitters are either transmitting data to mobiles or they are transmitting a code. When a mobile unit is turned on, it searches for the strongest signal from the available base stations each operating on a different frequency. When the mobile unit selects the best site, the mobile unit creates a message and transmits it to the receiver at that site, letting the system know that the mobile is listening to that site. There is no delay in outbound transmission while a transmitter gets up to power because the transmitter is on all the time. In addition, if the mobile moves so that it is out of range with the site it has been working with, the mobile searches for the best signal it can receive from any of the other sites. If it finds a better signal, then the mobile data unit creates a message again for the system to listen to the new site. In this way, the system knows what site to select to transmit a signal to the mobile. The difficulties with use of this method of data transmission are that more frequencies are required and there is a substantial period of time required while a mobile seeks a different site and logs onto that site and creates and transmits a message into the system saying it is on that site. If a message is directed to the mobile during that time, the mobile does not receive it and a number of retransmissions occur and they may occur before the mobile logs onto a new site so that the mobile never receives the message.

3.4 Range for a Government Network Using 50 kHz Bandwidth 700 MHz Channels

In general, the higher the data rate that is transmitted, the shorter the effective data communications radio range. That is because there is multi-path fading in any radio system and more of the message will be lost during a deep fade if the data rate is higher. At low data rates, forward error correction is often able to fill in for lost data, but at higher data rates, so much data is lost that the forward error correction cannot fill in the lost data and one or more packets, or an entire message, must be transmitted. If a mobile is in an area where there is any significant amount of multi-path fading, it may not be possible to ever get a message through at the higher data rates.

With this in mind, high data rate mobile data communications systems may need to utilize antenna diversity on the mobile, and also possibly at the fixed location radio sites. This can add about $800 per mobile to the cost of the mobile radios, but it is proven to result in a substantially increased effective coverage area due to the substantial reduction in deep multi-path fades at the mobile and at the fixed location end of the radio path. Use of antenna diversity also reduces the cochannel field strength differential required for capture of an FM radio signal, thereby reducing the distance separation before reuse of a frequency.